TECHNICAL MANUAL

USE AND GRADES OF DIESEL ENGINE LUBRICATING OILS

(ATOS)

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INTRODUCTION

1. PURPOSE.

The purpose of this Technical Order (T.O.) is to identify military specifications and grades of diesel engine lubricating oils recommended use in USAF equipment.

2. SCOPE.

The instructions contained herein provide information on the use of diesel engine lubricating oils and testing procedures for determining their quality.

3. TECHNICAL ASSISTANCE.

The Technical Division (WR-ALC/AFTT) of the Air Force Petroleum Office provides technical support as follows:

a. Provides technical advice and support on diesel engine lubricating oils and related quality problems. Contact DET 3, WR-ALC/AFTT, Wright-Patterson AFB, OH 45433, DSN: 785-8050, for assistance.

b. Prepares this technical order.

c. Maintains and operates Directorate of Aerospace Fuels laboratories which provide testing services to Air Force installations on samples of petroleum and related products. These laboratories and their areas of responsibility are specified in T.O. 42B-1-1.

CHAPTER 1
DIESEL ENGINE SERVICING

1.1 LUBRICATING OIL SERVICING LEVELS.

The oil reservoir filler opening on most diesel engines is located for easy access and provided with a dipstick to determine the oil level. Oil reservoirs will be serviced to the normal full level (with engine off), unless otherwise directed by the applicable equipment technical order or operational manual (i.e., some generator sets are equipped to read the oil level while running). Do not overfill.

NOTE

Frequently, agitation of the oil by the engine under normal operating conditions will result in the formation of considerable foam in oil reservoirs. Under such conditions, foam, if not permitted to settle, may cause erroneous determination of the oil level if checked by a dipstick or by visual observance.

1.2 METHOD OF SERVICING.

Diesel engines will be serviced using oil from servicing units, hermetically sealed cans, drums, or bulk storage tanks. Diesel engine oil serviced from servicing units or containers which are not hermetically sealed, will be filtered through a 60-mesh (or finer) screen.

1.3 MAINTENANCE PROCEDURES.

This technical order will specify required engine oils. If the requirements of this T.O. and the end item T.O. are in conflict, the end item Office of Primary Responsibility (OPR) will be advised to make corrections by referencing T.O. 42B2-1-11. The base vehicle inspection requirements can be found in AFI 24-301, Vehicle Operations.

1.4 DISPOSAL OF USED OIL.

The disposal of used oil drained from diesel engines will be managed In Accordance With (IAW) AFI 23-502, Recoverable and Unusable Liquid Petroleum Products, and T.O. 42B-1-23, Management of Reclaimed, Recoverable, and Waste Petroleum Products.

CHAPTER 2
DIESEL ENGINE OILS

2.1 LUBRICATING OIL GRADES.

In order to limit the proliferation of types and grades of engine oils for AF support equipment and vehicles and to insure the proper oil selection the following policy is established: Use of MIL-PRF-46167 or MIL-PRF-2104 Grade 15W-40 (based on environmental temperature) is recommended for all AF ground support equipment and vehicles with output ratings up to and including 750 horsepower (560 kW). These lubricants represent the state-of-the-art in engine lubricants and are significantly improved compared to oils previously available. These lubricants will provide adequate lubricant protection for AF service in all known industrial and vehicle engines within this power range.

This policy constitutes authority for using activities to deviate from end item T.O.'s and commercial manuals in the selection of engine oils. The only reasons to vary from this policy would be:

a. If the end item T.O. specifically prohibited the use of one of the required oils. If there is any doubt, contact the end item OPR and reference this T.O.

b. Equipment Under Warranty – some engine manufacturers, for proprietary reasons, have not approved the required oils. Most new equipment design requirements have specified the required oils and this should not be a major problem.

c. Required Oils Not Available, Other Stock on Hand, Local Preference, etc. – the oil specifications referenced in this T.O. represent the most advanced oils available and the quality control programs strive to ensure only the specified oils reach the supply system. The Army OPR for these lubricants conducted a large test of the off-the-shelf oil products and found many cases of off specification and a few of gross mislabeling. Local purchase of lubricants is not recommended and if required should be limited to nationally distributed name brands meeting the American Petroleum Institute service classification CF-2 for 2-cycle diesel engines and CI-4 for use in 4-cycle diesel engines.

2.2 OILS AUTHORIZED FOR USE.

a. MIL-PRF-2104 – the lubricants covered by this specification are intended for all conditions of service when ambient temperatures are above –18°C (0°F). These oils meet API service classification CI-4 for severe duty diesel engine service. This service includes supercharged diesel engines in high speed, high output duty requiring highly effective control of wear and deposits. These oils provide protection from bearing corrosion and from high-temperature deposits in supercharged diesel engines when using fuels of a wide quality range. Figure 2-1 lists available grades and recommended ambient temperature ranges. While all the grades are acceptable for use, Grade 15W-40 shall be used unless unusual conditions exist.

NOTE

The SAE J2362 and MIL-PRF-46167 oils are not recommended for use in large stationary diesel engines containing silver bearing surfaces.

b. SAE J2362 – the lubricating oils covered by this specification are intended for use in gasoline engines operated in administrative service.

c. MIL-PRF-46167 – this specification covers one grade (0W-30) of engine oil suitable for crankcase lubrication of all diesel engines used in cold and arctic conditions. See Paragraph 2.3, Step b for additional information.

d. A special proprietary engine oil is required for use in large diesel engines such as railroad locomotives and stationary diesel engines used for power generation. It is available only in Grade 40 and is specially formulated as a low zinc product for lubrication of engines with silver bearings and where fuel sulfur content does not exceed 0.5% by weight. The stock number for this proprietary product is listed in Table 2-1 and is only obtainable in a 55-gallon drum.

2.3 LOW-TEMPERATURE OPERATIONS.

a. For environments where the winter 10th percentile minimum temperatures (ref. Table VI in MIL-HDBK-113) do not go below –18°C (0°F), Grade 15W-40 of MIL-PRF-2104 can be used year-round in all diesel engines. Extra preheat/warm-up precautions must be taken when the temperature drops below –18°C (0°F).

b. For cold environments where the summer average daily high temperatures seldom exceeds 15°C (60°F) and the number of days with a high-temperature between 32°C (90°F) and 38°C (100°F) is limited, the oil of choice for year-round use is MIL-PRF-46167, a Grade 0W-30 synthetic

arctic oil. The minimum pumping temperature for this oil is approximately −51°C (−60°F). Preheat is recommended in below −45°C (−50°F) conditions and is mandatory below −51°C (−60°F). While the commonly accepted upper limit for this oil has been 4°C (39°F), Army hot weather testing of the latest formulation has confirmed acceptable performance in higher temperatures. Some stock of this oil produced before 1979 might still be in the supply system and it must not be used above 4°C (39°F). This oil has excellent high-temperature lubricity and stability and the only problems which might be encountered at temperatures higher than 32°C (90°F) would be low engine oil pressure at low rpm and seal/gasket leakage/weepage both occurring due to the low viscosity of this oil.

c. Lubrication oil grade and condition is an important factor in reliable cold weather diesel engine starting. With the exception of fuel dilution, age and contamination will cause the lubricating oil to thicken and increase cold starting difficulties. This can be minimized by adhering to proper oil change intervals and selecting the proper grade of oil.

d. Each diesel engine has a minimum cranking rpm to provide sufficient heat of compression to ignite the fuel when it is injected. As the temperature decreases, the minimum rpm increases due to the cold intake air and cold combustion chamber. Use of the low viscosity, Grade 0W-30 arctic oil will improve the cranking rpm and minimum wear and tear on the starting system in colder temperatures.

e. Cold starting diesel engines represents an additional strain on the internal components which can lead to reduced overhaul life. It is critical to initiate lubricating oil flow during the starting process to insure oil flow to the engine bearings (especially the rod and turbocharger bearings). Repeated cold starting with momentarily delayed oil flow because the oil is too thick will eventually lead to rod and/or turbocharger bearing failure. Some end items, notably the Mobile Electric Power (MEP) generator sets, are designed so the engine goes directly to synchronous or high idle rpm as it starts. With this system, it is critical to establish oil flow immediately. The oil on the oil level dipstick should always be checked to insure the oil is fluid enough to flow. Hot air blast heating or externally powered oil heaters should be used if there is any doubt.

f. An option to repeated cold starting is to let the engine(s) run at high idle or synchronous rpm during cold weather when they will be needed in a few hours. This has been used regularly by commercial diesel users and represents less mechanical wear and tear on the engine and starting system but is hard on the oil because moisture (and thus acid) builds up in the oil. More frequent oil changes, about half the normal time, will be required for engines subjected to frequent no load operation. If possible, the engine should be run at full output for a minimum of one-half hour after prolonged no load operation to boil off the moisture accumulation and minimize the detrimental effects.

CAUTION

Seasonal oil changes shall be accomplished if the environmental temperature at any location exceeds the allowable extremes noted for the 2 standardized oils.

g. Standby, low utilization, and WRM type end items should use the arctic oil if there is any chance the engine will be started with the oil temperature below −18°C (0°F).

Table 2-1. Diesel Engine Oils

NATO					
Specification	**Nomenclature**	**Grade**	**Code**	**NSN**	**Container Size**
SAE J2362	Lubricating Oil, Automotive Engine, API Service SJ for Military Administrative Service	10W		9150-00-186-6682	Quart can
				9150-00-186-6685	55-gallon drum
		30		9150-00-186-6689	Quart can
		5W-30		9150-01-278-1357	Quart can
				9150-01-278-1356	12-quart pail
				9150-01-348-1596	55-gallon drum
		10W-30		9150-00-186-6699	Quart can
				9150-01-227-8210	12-quart pail
				9150-01-230-9749	5-gallon pail
				9150-01-230-9748	55-gallon drum
				9150-00-451-6947	Bulk
		15W-40		9150-01-289-0825	5-liter pail
				9150-01-352-2962	5-gallon pail
				9150-01-351-9018	55-gallon drum
MIL-PRF-46167	Lubricating Oil, Internal Combustion Engine, Arctic		O-183	9150-00-402-2372	5-gallon pail
				9150-00-491-7197	55-gallon drum
Proprietary	Lubricating Oil, Engine, Low Zinc	40		9150-00-135-2634	55-gallon drum
MIL-PRF-2104	Lubricating Oil, Internal Combustion Engine, Tactical Service	10W	O-237	9150-01-177-3988	12-quart can
				9150-00-186-6668	5-gallon pail
				9150-00-191-2772	55-gallon drum
				9150-00-183-7807	Bulk
		30	O-238	9150-01-178-4726	Quart can
				9150-00-188-9858	5-gallon pail
				9150-00-189-6729	55-gallon drum
				9150-00-183-7808	Bulk
		40		9150-00-189-6730	Quart can
				9150-00-188-9862	55-gallon drum
				9150-00-405-2987	Bulk
		15W-40	O-1236	9150-01-152-4117	Quart can
				9150-01-178-4725	24-quart pail
				9150-01-152-4118	5-gallon can
				9150-01-438-6082	5-gallon can (re-refined)
				9150-01-152-4119	55-gallon drum
				9150-01-432-4309	275-gallon bulk container

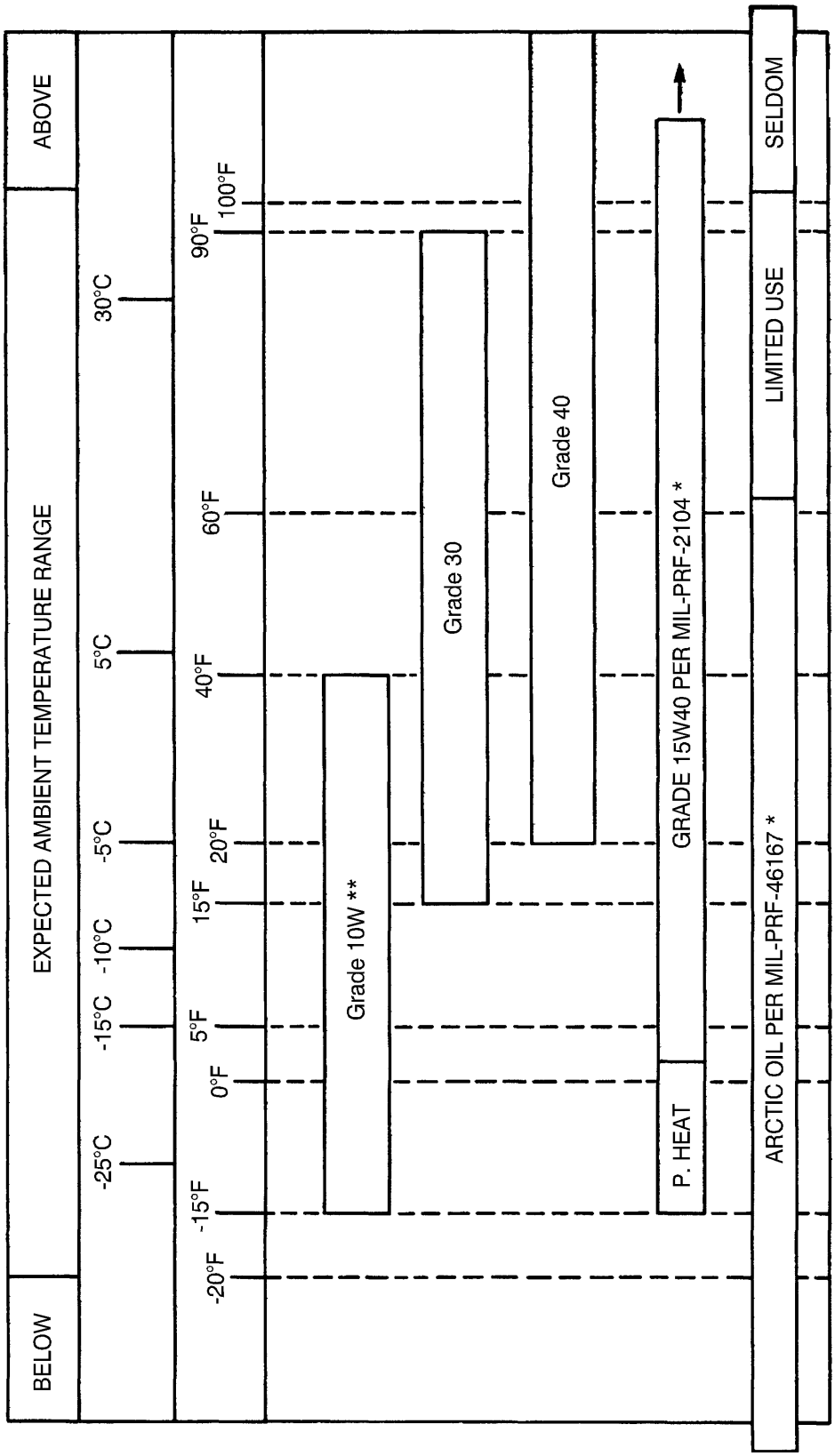

Figure 2-1. Recommended Ambient Temperature Range MIL-PRF-2104 and MIL-PRF-46167

CHAPTER 3
GENERAL ENGINE REQUIREMENTS

3.1 GENERAL INFORMATION.

a. MIL-HDBK-113, Guide for the Selection of Lubricants, Functional Fluids, Preservatives, and Specialty Products for Use in Ground Equipment Systems, is a good reference source for information on all DoD lubricant specifications used with ground equipment.

b. MIL-HDBK-114, Mobility Fuel User Handbook, is a good reference source for information on all DoD fuel specifications used with ground equipment. As the Military has been mandated to use commercial products such as fuels, the Chevron Technical Bulletins (for Aviation Fuels, Diesel, and Gasoline) can be used as references. These Technical Bulletins are free and can be downloaded from the Chevron website (http://www.chevron.com/).

c. General Motors 149 and EMD type engines and other large real installed property diesel engines usually require low zinc oil. Consult specific equipment/engine technical orders or appropriate commercial manuals for oil requirements. Contact The Field Support Directorate, known as the Civil Engineer Maintenance, Inspection and Repair Team (CEMIRT). The directorate has three regional offices. One located next to HQ AFCESA at Tyndall and two geographically separated Operating Locations (OL's). Contact one of the regional offices at the following addresses for additional information about the large diesel engines.

- Tyndall, Southeastern Region: DSN 523-4291
  Tyndall: HQ AFCESA/CEMR
  1001 Mississippi Rd
  Tyndall AFB, FL 32403-5319
- Dover, Northeastern Region: DSN 445-6161
  Dover: OL-A AFCESA/CEMIRT
  922 Arnold Dr
  Dover AFB, DE 19902-5922
- Travis, Western Region: DSN 837-5211
  Travis: OL-E AFCESA/CEMIRT
  730 E Street
  Travis AFB, CA 94535-2405

3.2 OIL CHANGE INTERVAL.

Because there are many different types of diesel engines operated under various conditions of service and environments, a universal oil change interval cannot be established. Change oil at the interval specified by the equipment technical order, commercial manual or AFI 24-301, Vehicle Operations, unless conditions of service require that the oil be changed more frequently. The following guidelines should be followed:

a. Change the oil immediately if it is found to be contaminated with water or antifreeze. Also, the engine should be thoroughly inspected to determine the cause of such contamination.

b. A decrease in viscosity usually indicates fuel contamination. Most diesel engines have fuel lines in oil wetted portions of the engine so the possibility of contamination is always present. The source of the fuel leak must be located and repaired as soon as possible. An increase in viscosity indicates oxidation and/or other contamination. As a general rule, a viscosity change of 25 – 30% from the original unused value should be cause to change the oil. Because the specification allows a range of viscosity values for a given grade, the used oil must be compared to an unused sample to determine the actual condition.

c. Low utilization and standby diesel engines in support equipment can be waivered to increase the oil change interval to require only an annual oil change. This can be extended to 2 years if a complete oil analysis, with special emphasis on total acid and base numbers, shows the oil to be serviceable. The determination of what is considered low utilization on any equipment item is left up to each maintenance command. Any waiver to increase the oil change interval must be approved and documented by each associated command quality assurance section. Engines used in low utilization or standby type of service should occasionally be run at variable power settings until they have reached normal operating temperature to minimize moisture/acid buildup in the oil.

d. The diesel fuel sulfur content has a major impact on the acid buildup and depletion of acid neutralizers in crankcase oil. In CONUS, the sulfur content by weight of diesel fuel is less than 0.05%, by specification. This is not true in OCONUS where sulfur fuel content can exceed 1.0%. As a rule, the oil change interval of an engine's crankcase oil should be cut in half as the sulfur content of the diesel fuel approaches 1.0% by weight. The fuel sulfur content cannot be checked by a simple test. If there is any doubt of the sulfur content in the fuel being used, have a fuel sample sent to a laboratory to be tested for sulfur content.

e. Always approach oil change interval from a conservative standpoint and change the oil more frequently if there is any doubt as to its serviceability. An oil change is always less expensive than an engine change.

Table 3-1. Correspondence between Specification and SAE Oil Grades

Specification	Specification Grade Designation	SAE Grade Classification
MIL-PRF-2104	10W	SAE 10W and SAE 10W-20
	30	SAE 30
	40	SAE 40
	15W-40	SAE 15W-40
SAE J2362	5W-30	SAE 5W-30
	10W-30	SAE 10W-30
MIL-PRF-46167	Arctic	SAE 0W-30

CHAPTER 4
SAMPLING LUBRICATING OIL FROM DIESEL ENGINES

4.1 SAMPLING AND TESTING IN-USE ENGINE OIL.

Because the AF uses a wide variety of different diesel engines in many different service conditions, and AF wide standardized formal oil analysis program cannot be established (see Paragraph 5.2). Local oil analysis programs confined to a limited fleet of engines used in similar service conditions can be beneficial in detecting contamination and establishing oil change intervals. Local programs must be approached very cautiously and oil change intervals established based on a significant history of oil performance. Also local programs must establish oil change intervals on a complete range of oil tests not just wear metals. Indications of contamination from coolant, fuel, dirt, soot, and other sources should be investigated. An immediate oil change may be required to preserve engine performance. When it is necessary to test lubricating oil for contamination, a representative sample will be taken from the oil system as follows:

a. Prior to sampling, operate the engine for 15 minutes to 1 hour to uniformly distribute any foreign material in the oil.

b. A 1-quart sample shall be drawn from a running line such as the oil supply line between the oil pump and oil filter or from the filler-neck or dipstick opening by means of an oil thief or from the reservoir drain. A thief is a device such as a plastic or metal tube (glass tubing is never to be used) which may be inserted through the filler-neck and dipstick opening. When a tube is used, close the exterior end after inserting in the oil and keep closed while withdrawing in order to retain the sample. The filler-neck or dipstick opening shall be protected from rain, dust, etc. while sampling.

c. In order to obtain a representative sample from the reservoir drain, discard the first pint of oil.

d. Oil analysis guide:

Analysis Reading	Contaminant	Correct
Silicon (Si)	Dirt	Air Filter Oil Breather
Sodium (Na)	Antifreeze	Coolant Leak
Viscosity Increase	Soot/dirt Old oil	Change Oil
Viscosity Decrease	Fuel	Leak/Change Oil
Wear Metals	Each engine will require analysis	
High Magnesium (Mg)	Often used in base oil for acid neutralization	

4.2 SAMPLE SOURCE.

The source of samples will vary with the relationship of the oil to the suspected problem. Therefore, the sample shall be taken so as to provide a true indication of the suspected problem. Also, a 1-quart sample from the unused operating stock will be submitted with the sample from the engine reservoir to serve as a basis for comparison. When it is not possible to obtain drain or THIEF samples (for example after an accident), the sample will be taken by any means possible with the intent of the oil drained from the engine due to suspected contamination. Clean equipment should be used for draining and sampling to provide a representative sample for analysis.

4.3 SAMPLE CONTAINERS.

Samples will be taken in pint or 1-quart containers. Funnels may be necessary to fill the sample container. The sampling equipment and supplies (funnels, containers, sample thieves, etc.) shall be cleaned prior to use to avoid contamination of the samples.

4.4 SAMPLE IDENTIFICATION.

Each sample shall be properly identified as to its source. Sample tags, AFTO Forms 475, will be used for this purpose. The tags shall be securely fastened to the sample container. Identify the diesel engine from which the sample was taken by serial number. Indicate source of the oil sample (i.e. tank, tank drain), number of hours or miles since the last oil change, etc. A letter to the laboratory explaining why the samples were taken shall accompany or precede the sample.

4.5 SAMPLE SUBMISSION GUIDE.

Air Force activities should submit samples to the supporting area Aerospace Fuels Laboratory IAW T.O. 42B-1-1. Contact the DET 3, WR-ALC/AFTT, Wright-Patterson AFB OH, DSN: 785-8050, if additional technical support or guidance is required. Local SOAP labs can check diesel engine oil for wear metals but are usually not equipped to perform the complete range of tests necessary to determine if the oil is serviceable. Oil change intervals must not be based only on wear metals analysis.

4.6 SAMPLING EQUIPMENT REQUIRED.

Item	NSN
Bottle, 500mL, polyethylene	8125-00-877-8108
Can, 1-pint	8110-00-178-8280
Can, 1-quart	8110-00-178-8281
Kit, oil sampling, two 4-oz glass bottles/and mailing container	6695-00-925-2982

CHAPTER 5
QUALITY CONTROL

5.1 PACKAGED PRODUCTS.

The quality control management procedures for inspection and testing of unopened packaged petroleum products are contained in T.O. 42B-1-1. Diesel lubricating oils are inspected and tested under the provisions of this technical order to maintain supply stocks in usable condition.

5.2 ENGINE OIL IN USE.

A formal engine oil analysis program has not been established; however, there are conditions of severe use or prolonged inactivity which can cause local concern regarding the quality of the oil being used in the engine. Basic factors which are used to determine the condition of the oil are summarized below:

a. Oil Viscosity – a viscosity test indicated whether the proper grade of oil is being used. It can also be used to determine oil degradation or contamination. An increase in viscosity indicates oxidation of the oil and a decrease in viscosity indicates fuel dilution. The oil should be changed when the viscosity changes 25 – 30% from the unused value.

b. Contamination – water or glycol contamination from the engine cooling system can cause problems such as engine overheating, loss of lubrication, and corrosion.

c. Neutralization – new engine oils are formulated so they are capable of neutralizing the acidic compounds that form from products of combustion and oil oxidation. This reserve alkalinity can become depleted, allowing acidic oil to attack bearing surfaces. Total Base Number (TBN) and Total Acid Number (TAN) are important measures of oil condition/degradation.

d. Insolubles – this type of test measures oil insoluble materials, i.e., (1) oil resinous matter from oil or additive degradation, (2) fuel carbon and carbonized materials from degradation of fuel, oil, and (3) engine wear and corrosion materials.